POZNAN UNIVERSITY OF TECHNOLOGY

EUROPEAN CREDIT TRANSFER AND ACCUMULATION SYSTEM (ECTS)

COURSE DESCRIPTION CARD - SYLLABUS

Course name
Applied Thermodynamics [S2EPiO1>TT]

Course

Field of study
Industrial and Renewable Energy Systems

Year/Semester
1/1

Area of study (specialization)
Gas Technology and Renewable Energy

Profile of study
general academic

Level of study
second-cycle

Course offered in
Polish

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture
15

Laboratory classes
0

Other
0

Tutorials
15

Projects/seminars
0

Number of credit points

2,00

Coordinators

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Lecturers

Prerequisites

Student should have basic knowledge in mathematics (integration, differentiation) and in physics, also in thermodynamics (first course). Should be able to obtain information from the library and internet, should be ready to cooperate in a team.

Course objective

The purpose of the course is to deepen the student knowledge on thermodynamics and to prepare him to solve more complex problems. The purpose of the subject is also to draw attention to the issue of ecology.

Course-related learning outcomes

Knowledge:
1. student has a knowledge which allows him/her to analyze, design and optimize the thermodynamic processes.
2. student has a knowledge which allows him/her to describe mathematically and optimize the thermodynamic processes.
3. student has a knowledge of new energy-saving technology in the field of thermodynamics.

Skills:
1. student knows how to find a source of knowledge which enables him/her to analyze and solve the considered thermodynamic problem.
2. student knows how to formulate the hypotheses concerning the studied thermodynamic problem.
3. student knows how to use the results of experimental and numerical investigations to optimize the thermodynamic processes.

Social competences:
1. student is able to critically assess the received information in the field of thermodynamics.
2. student is prepared to operate effectively in the field of thermodynamics.
3. student knows his/her role in society and is ready to work effectively in the field of thermodynamics to fulfill expectations.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Learning outcomes presented above are verified as follows:
Lecture: knowledge acquired during the lecture is verified by a 90-minute colloquium.
In tutorial class the knowledge is verified by a final test.

Programme content

The I and II law of thermodynamics. The free enthalpy and free internal energy. The Maxwell's thermodynamic equations. The theoretical and actual combustion processes. The enthalpy of formation and enthalpy of combustion. The behavior of gas mixtures (ideal and real gases). The basic consideration in the analysis of power cycles. The vapor and combined power cycles (energy balance, efficiency, losses). The binary vapor cycles. The basic processes of humid air. The heat exchange: Conduction (in materials with an internal heat source). The free convection (laminar free convection, the effect of turbulence, empirical correlations). The combined free and forced convection. Boiling and condensation (the boiling curve). The force boiling convection, two face flow. Radiation (processes and properties, radiation exchange between surfaces).
Tutorial classes: solving practical problems (the first and second law of thermodynamics, power cycles, efficiency). Calculations of the air demand in combustion processes, exhaust composition. Calculations of adiabatic dryers

Course topics

The examples of heat processes occurring in technology and nature. The basic physical parameters used in thermodynamics, i.e. pressure, temperature, volume, mass, and their units. The ideal gas equation of state (individual gas constant, universal gas constant). Definition of work and heat of dissipation. The external reversible work and the technical reversible work. The state functions: internal energy and enthalpy. The first law of thermodynamics (closed system). The specific heat at constant pressure and specific heat at constant volume. The molar specific heat. The dependence of specific heat on temperature. Computational examples from the scope of the first law of thermodynamics and the ideal gas equation of state. The first law of thermodynamics, open system, computational examples. The next state function: entropy. The second law of thermodynamics, entropy increase. Irreversibility of the thermodynamic processes, spontaneous processes - examples. Analysis of the basic thermodynamic processes: isobar, isochore, isotherm - examples with simple technical applications. The isentropic process. The external and technical reversible works along the isentrope. The polytropic process, polytropic heat, example - two-stage compressor with interstage cooling. The deal gas mixtures, constitutive equations (Dalton's law). Examples. The cycle equation and thermal efficiency of the cycle. Carnot cycle and Brayton-Joule cycle (with regeneration). The isentropic efficiency of the compression and expansion processes. Computational examples. The phase changes of water, the (s, h) diagram of wet and superheated vapor. Rankine cycle - computational example. The thermodynamics of humid air, basic parameters: absolute humidity, relative humidity, moisture content, dew point. Mollier diagram. The technical applications: air conditioning and drying. The computational examples. Thermodynamics of the combustion process. The heat transport methods: conduction, convection and thermal radiation. Fourier's law, the thermal conductivity coefficient. The heat conduction through the flat plates and through cylindrical pipes. The thermal conductivity equation (the solutions of chosen flow examples). The heat conduction with an internal energy source - examples. Newton's law, the heat transfer coefficient and its unit. Computational examples. The natural convection and forced convection. Similarity numbers: Reynolds, Prandtl, Nusselt, Grashof. The empirical dependencies on the Nusselt number - computational examples. The thermal radiation and its basic parameters (emission density, the ability of matter to reflect radiation, to absorb it and to transmit). Stefan-Boltzmann law. Emissivity. The heat exchange by radiation between two infinitely long plates perpendicular to the ground. The heat exchange by radiation between real bodies. Screens. Radiation of liquids and gases.

Teaching methods

Lecture: multimedia presentation illustrated with examples on the board.
In the classroom (tutorial), the practical problems are solved on the board.

Bibliography

Basic
1. Szargut, J. Termodynamika, PWN, Warszawa, 2000.
2. Demichowicz-Pigoniowa, J., Obliczenia fizykochemiczne, PWN, Warszawa, 1984.
3. Wiśniewski, S., Wiśniewski, T., Wymiana ciepła, WNT, 2002.
4. Szargut, J., Guzik, A., Górniak, H., Zadania z termodynamiki Technicznej, Wyd. Politechniki Ślaskiej, Gliwice, 2011.
5. Furmański, P., Domański, R., Wymiana ciepła, Przykłady obliczeń i zadania, Oficyna Wydawnicza Politechniki Warszawskiej, 2002.
Additional
1.Cengel, Y., Boles, M.A., Thermodynamics, an engineering approach, Mc Graw Hill, 2008.
2. Incropera, F., DeWitt, D., Fundamentals of heat and mass transfer, Wiley, 2008 3. Ghiaasiaan, M., Convective heat and mass transfer, Cambridge University Press, 2014
3. Ghiaasiaan, M., Convective heat and mass transfer, Cambridge University Press, 2014

Breakdown of average student's workload

	Hours	ECTS
Total workload	65	2,00
Classes requiring direct contact with the teacher	35	1,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	30	1,00